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Calligonum polygonoides: Keystone Species of the Thar Desert Ecosystem

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ABSTRACT

Calligonum polygonoides belongs to family polygonaceae is a shrub plant found is Indian Desert. It has several traditions as a uses such as food, fodder, fuel wood and as a medicine. It contains Phytochemical and marked many climax species of ecosystem. Rural people depend on it for their livelihood. The plant is now listed been as endangered plant. An attempt has made review its ecological and Pharmacological values. Further, its conservation and development of propagation technique is the need of era.

Keywords: *Calligonum polygonoides*; Polygonaceae; Keystone species; Phytochemical; Antibacterial; Climax species; Soil binder; Phytochemicals; Antibacterial activity; Antifungal activity.

1. Introduction

Calligonum genus was established by Linnaeus (1753) which is represented by 158 species (The plant list 2013) mainly distributed in North Africa, China, Asia (Pakistan, India and which too Afghanistan) and South Europe of Species are reported from India *Calligonum polygonoides* L and *Calligonum comosun* L'Her. Another name of *Calligonum* species of *Calligonum crinitum* is reported from India (Purohit & Ramesh 2020).

Taxonomic key of the genus *Calligonum* in India-

1) *Calligonum polygonoides* - Its leaver are longer, 8-16 mm lay, flowering pedicel longer than the perianth lobes. Nut 9-10 x 4-5 mm, oblong usually longer than broad.

2) *Calligonum commosum* - Its leaves are smaller, 1-6 mm long, flowering pedicel usually smaller; rarely equaling the perianth lobes. Nut 7-8 x 2.5 to 3 mm, fusiform.

3) *Calligonum crinitum* - Its fruit are with setae 20-30 mm long across. Setae of the fruits not arising on well-defined wings but directly from the fruit.

Calligonum polygonoides belongs to family polygonaceae It is commonly known as pleng or phogla" in deserts of Rajasthan. It is on small shrub. It is found Southern Trans-Indus plains, Baluchistan, Thar and Cholistan desert areas. It is about 1 to 2 meter in height with a girth of 30 to 60 cm (Jussieu A. 2001). It may even grow in adverse condition of moisture and soil but grows normally on dry sandy soils and on Sand dunes (Khan, 1997).

Its leaves are very scanty, sessile, minute linear and for caduceus, 7-15 mm long, linear spathulate, stipules are very short membranous, obliquely amplexicaul. Its flowers are pink pedicellate, pedicel 3-8 mm long, slightly accruement in fruit. Perianth 2 mm long, 2-3 mm broad cleft about two-third the way down. Segments are 5, obovate, thin, membranous, red with broad white margin stamens 12, filament swollen, hairy and connate at the bare. Its fruit are densely clothed with branched bristles with dilates often confluent bases. It produces root sucker and is easily propagated by cutting and layering.

This tree/shunt is also named aorta in old arabic poems agues so large number of people agrees that origin of aorta for great human artery. It is very hardy and being capable of growing under adverse conditions of Soil and moisture. It is a dominant perennial shrub in active sand dunes and stabilized sand fields in most desert area.

1.1. Study Objective

The main objective of the paper is to explore various uses of *Calligonum polygonoides* with respect to its utilization and importance in desert ecosystem. This paper reviews the various works carried out and further need of the research on the species to make it more useful for environment and livelihood.

1.2. Distribution

It is geographically widely distributed shrub seen from the arctic to the tropics. Major concentrations are gained in Northern temperate region by most of the species (Heywood, 1978). Its worldwide distribution is found throughout the North Africa, Southern Europe, Africa) Central and western Asia as main diversity centre (Brandbyge, 1993). In western Asia, its distribution is found in the desert region Rajasthan and southern Punjab in India. Northeast-Afghanistan, Boogtee hill in Pakistan, Armenia, Persia and Syria (Kumar et al., 2015).

According to Shetty and Singh (1991) genus *Calligonum* with species *polygonoides* in out of 4 genera of polygonaceae which are distributed in Thar Desert of Rajasthan naturally (Shetty and Singh, 1991; Bhandari, 1995).

Arid region of Rajasthan covers from 24°N to 35.5°N and 70.7°E to 76.2°E. *Calligonum polygonoides* shows its presence in Jaipur, Barmer, Churu, Bikaner, and Jodhpur and Jaisalmer district. Its growth on sand dunes as a psammophtic vegetative of Barmer, Churu, Bikaner, Jaisalmer, Jhunjhunu, Nagaur, Sikar and Shri-ganganagar is also reported. Cross pollination (anemophily) of plant is also reported (Raju et al., 2001) which might be the reason of high density at chemical as well as molecular levels (Katewa et al., 2005). Some worker analyzed RADP marker of *Calligonum polygonoides* and reported that plant showing diverse accessions of spreading and occupying geographic niches in arid region is due to predominantly obligate out breading behavior (Bewal et al., 2009).

Calligonum polygonoides bestowed the status of the keystone species of the Thar Desert ecosystem (Vyas et al., 2012). It provides different economic, ecological and medicinal services for human welfare (Swarnkar et al., 2019; Rauf et al., 2022). *Calligonum polygonoides* belong to family polygonaceae which is also known as Buckwheat, smartweed or knotweed family (Srivastava 2014; Uddin et al., 2014).

1.3. Climax Species

Ecological succession in the gradual process of development of an ecosystem over time in a particular geographical area with respect to species and their habitat (Walker et al., 2009; Sun et al., 2023). The final stages of succession is called as climax and the species are called K-selection species or climax species (Clement 1936; Shimwell 1973). These climax species are very specific well adapted and dominating among other species in their climatic conditions. *Calligonum polygonoides* L is a climax woody plant species of the xeric ecosystem. In the harsh desert conditions its morphological and anatomical structure shows its well adaptation and it's grow on longitudinal

transverse and parabolic sand dunes as a major plant among other psammophytic scrub plant communities (Saxena et al., 1976).

1.4. Botany

Its mixture plants have a lignified stem which is erect, aerial, smooth, green and modified into phylloclade for survival (Swarnkar et al., 2019; Purohit et al., 2020). Its vegetative branches are deposited with lignin that forms the browny and shiny skeleton of the plant (Ahmed et al., 2016). Leaves of plants are either reduced or absent and the plant become leafless as an adaptation to the harsh condition of desert (Charan et al., 1979; Rajpurohit et al., 1979). Roots of *Calligonum polygonoides* are large, well developed. Roots are deep penetrating, branched, tapped and extend to a depth of more than 1.5meters. Its superficial roots are horizontally present with fan shaped lateral roots that extend by 10-20 meters (Ahmed et al., 2016). Its fruit are small succulent, regular, oblong with wing like appendages (Samejo et al., 2013). Due to harsh climatic condition plant adopts some special anatomical features. Thick cuticle, hypodermis, completely arranged parenchymatous tissue, druses in cortex and pith, solidified pith tissue and continuous ring of the vascular bundle with xeric adaptation in the stem are some remarkable anatomical features. They are highly susceptible to the threat of extinction at any changes in their habitual environment (Swarnkar et al., 2019; Bibi et al., 2014; Mohmed et al., 2020).

1.5. Keystone species of Arid Ecosystem

Calligonum polygonoides is the keystone and dominating species of Indian arid thorn forest. This species was first coined by Paine (Paine 1969) as a stabilizer species of a community. It is another low abundant species from the dominating species of an ecosystem whose elimination causes drastic changes in community structure and also lead extinction of other species (Ebrahimi et al., 2022).The plant stabilizes and fulfill the demands of the residential community by providing different ecological and economic services (Gehlot et al., 2014; Khan et al., 2023).

1.6. Soil binder

Calligonum polygonoides is a good soil binder plant that settles down the sand and avoids further increase of desertification. Its soil binding capacity through a large rot system prohibits soil erosion and raises the organic matter in the sandy soil to increase soil fertility and thus useful plant for farmer (Shekhawat et al., 2012; Bewal et al., 2009). The fully mature plants show an allelopathy effect which either facilitates or suppresses the growth of other plant species that grow under its canopy (Ahmed 2020). It is reported that *Calligonum polygonoides* is a nurse plant that has the capacity to improve soil conditions and act as a facilitator (Rathore et al., 2015; Moshizi et al., 2019). It inhibits the growth of Echinochloacrus-Galli, *Abelomoschus esculentus, Helianthus annuus, Cucumus sativus* and *Brassica oleracea* under the canopy (El-amier et al., 2014; Khan et al., 2017). The plant also stabilize the food web of the desert ecosystem as a dominant producer under extremes of concurrent abiotic stresses of the sandy areas (Vyas et al., 2012; Khan et al., 2013).

1.7. As food

Its flower buds and Succulent fruits are important sources of food for sustaining during frequently occurring food scarcity in India and Pakistan (Goyal et al., 2008; Pervaiz 2020). Its unripe fruits have & carbohydrates (71.1

percent), fat (64 patent), protein (18 percent), fiber (9.1 percent) vitamin B2 (0.7 mg/100 gram), calcium (670 mg/100gm), iron (12.7mg/100gram) and phosphorous (420mg/100gm) (Choudhury et al., 2003, Tewari 2016). Flower buds of *C. polygonoides* called as "Phugusi" are rich source of sugar, nitrogenous components and proteins (Ahmed et al., 2016; Singh et al., 2010; Zouari et al., 2012). These buds are cooked either in fresh form or mixed with buttermilk or salt to make "heat - relieving raiyta" in dried form (Pullaiah et al., 2017). Its flowers are cooked with butter or coconut oil to make a local delicacy (Bewel et al., 2008). Beside this its buds and fruits are also used as folder (Samejo et al., 2013; Bewel et al., 2009; Yawer et al., 2007).

Overall *Calligonum polygonoides* is used in traditional system for various purposes. Its flower buds for preparing rayta, young branches are chewed to quench the thrust. Its young green branches and fruits are nourishing feed for camel, sheep, goat & cattle. Its branches & roots are used for fuel wood. Coal prepare from the wood has high calorific value and used as chief source of fuel wood in rural areas (Nasrullah et al., 2012). Whole plant is used as live hedge to demarcate boundaries of agriculture fields and to protect home yards and ropes from domestic and wild animal (Swarnkan et al., 2019). Its flowers used for worship in gangaur festival. Its branches as mulch during summer in the crop field as mulch (Choudhary et al., 2022). In traditional system its branches, root, flowers, buds are used as medicine for the treatment of stomach ailments, as well as therapeutic agent against many disorders such as typhoid, asthma cough and cold. It is also included 10 medicinal plant/herb to be used in "charakprogeemine" (Ahmed et al., 2016; Purohit et al., 2020; Sher et al., 2020).

2. Propagation

It is conventionally propagated through cutting, layering and rarely by seeds. However this conventional system has an insufficient production rate due to poor cutting survivability during plantation and low viability of hairy seeds. Due to extensive cutting, putting down roots and modifications to the conventional farming system its natural germplasm as well as community are losing. Consequences to all those it has been enlisted in the Red data book of IUCN as endangered plant species (Singh 2004). In vitro propagation technique of biotechnology can provide an efficient way of propagating *Calligonum polygonoides*.

3. Phytochemicals

Two butanolises *Calligonum* A and B was isolated (Yawer et al., 2007). They also isolated anew steroidal ester from the whole plant of *Calligonum polygonoides.* Several other compounds were isolated from the plant by various workers and pharmacological activities were also reported by various workers. Presence of phytochemical like alkaloids, flovonoids and phenolic compounds provides diverse pharmacological activities. They are –

(a) Antibacterial activity - It is reported that various fractions of *C. polygonoides* exhibits antibacterial activities against both gram positive and gram negative bacteria. The growths of *Bacillus subtilis, Staphylococcus aureres, Pseudomonas aeruginosa,* and *Klebsiella pneumonia* was inhibited by the methanolic, methylenechloride, n-hexane, ethyl acetate and n-butanol fractions of *C. polygonoides* (Khan et al., 2017; Ahmed et al., 2015). Its ethanol extract exhibits antibacterial activity against only *E. coli* and *Staphylococcus aureus* (Mukhtar et al., 2018). Crude extract of plant and its ethyl acetate fraction shows &non-inhibitory effect while chloroform fraction shows 7mm inhibition against *E. coli* (Shinwari et al., 2019).

(b) Antifungal activity - Due to presence of phenolic compound plant is traditionally used as antifungal agent. Its methanolic extract shows 70 percent, 50.7 percent and 50.7 percent inhibitory effect on *Aspergillus niger*, *Aspergillus flavus* and *A. fumigatus* respectively (Khan et al., 2015; Ahmed et al., 2019). Ethyl acetate, n-hexane and n-butanol fractions of *Calligonum polygonoides* showed antifungal activities against *Aspergillus fumigatus* while methylene chloride fraction shows activity against both *Aspergillus fumigatus* and *Candida albicans* (Khan et al., 2017). Its crude extract and ethyl acetate showed an 8 mm inhibition zone while n-butanol fraction showed 10 mm Zone of inhibition against *F. oxysporum* and the n-hexane and chloroform fractions showed 11 mm inhibition against *A. alternate* (Shinwari et al., 2019).

(c) Antioxidant activity - *Calligonum polygonoides* found effective against free radicals and super oxides due to presence of polyphenol and flovonoids in it (Berwal et al., 2021). Its methanolic extracts show significant scavenging of free radicals against DPPH, ABTS and super oxide at 78.1 percent, 83.1 percent and 36 percent respectively (Khan et al., 2015). On quantification of activity it was found to contain 55.84 mg RE/gm extract flovonoids which exhibited a highest metal chelating capacity (Parvaiz et al., 2020).

(d) Allelopathy effect - Allelopathy is a biological process that naturally suppresses weed growth by reacting chemically with both plants and microbes to overcome competition (Roy et al., 2019; Zhang et al., 2021). High concentration of tannins (7.58 mg/gram dry weight), saponin (17.33 mg /gm dry weight), flovonoids (6.86 mg/gm dry weight) and phenolic (8.14 mg/gm dry weight) were responsible for allelopathy (Abd et al 2020) Besides that simultaneous action of several compounds such as lipoxygenase, alkaloid, proteins, steroids; tarpenols and essential oil were also the reason behind allelopathic effect.

It was found that methanolic extracts of *C. polygonoides* at concentrations of 75 mg/liter showed a 60.42 percent inhibitory effect on seed germination of Echinochloa Cones-galliand 99.12 percent and 67.10 percent on root & shoot growth respectively (Soliman et al 2018). Seed germination and seedling growths of *Abelomoschus esculantus*, *Helianthus annuas*, *Cucumus sativus* and *Brassica oleracea* were also found in habited by *Calligonum polygonoides* (Khan et al., 2013 & 2017).

(e) Cytotoxicity - The cytotoxic activity of *Calligonum polygonoides* revealed information about its anti-cancer and anti-tumor potential (Khan et al., 2015). Cytotoxicity of flovonoids at different concentration (6.25, 25, 50 and 100 mg/ml) was estimated against human cancer cell lines i.e. liver Hep G2 & breast MCF-7 cancer. It was found that ‘Quercetin' a type of flovonoids expressed remarkable cytotoxicity against MCF-7 and Hep G2 cell lines with IC50 values of 0.87 and 4.88 mg/ml respectively (Purohit et al., 2020). Methanolic extract of *C. polygonoides* showed strong toxicity (80 percent death at 1000 Hg/ml of extract) in the brine - shrimp lethality test (Samejo et al., 2013; Khan et al., 2015).

(f) Haematological activities - Ethanolic extract of *C. polygonoides* (roots and stem) make changes various haemetologicalin attributes. It increases the Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Volume (MCV) while decreasing the count of red blood cell (RBC), Mean Corpuscular hemoglobin concentration (MCHC) and Platelets (Yasin et al., 2021). The methanolic extract of plant activity of showed inhibitory effect against the ACHE activity of krait venom (Ahmed et al., 2016).

4. Conclusion

Calligonum polygonoides is an important plant of arid region. Due to its over exploitation and loss of natural habitats it is now rated as endangered plant in IUCN book despite of global efforts underway to protect a conserve genetic resources this species is still unexplored. It has traditional and medicinal uses. There is an urgent need to conserve plant which is a keystone woody plant of Indian arid zone.

5. Future Suggestions

Being important plant with multipurpose uses its seeds from different agro climatic zone should be collected and with pre-treatment as well as putting seeds under less than 10% moisture cold storage and checking their viability is suggested. Further study on its utility also need of era.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in the literature review, analysis, and manuscript writing equally.

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